

APPARATUS AND METHOD FOR SEPARATING/MIXING  
PARTICLES/FLUIDS

[0001] This application claims priority on Canadian  
Patent Applications No. 2,421,246, filed on February  
5 12, 2003, No. 2,419,451, filed on February 21, 2003,  
and No. 2,435,086, filed on July 18, 2003.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention generally relates to  
10 the separation and mixing, of particles and, more  
specifically, to a dry particle stream separator/mixer  
and methods for separating particle streams into  
particle groups and for mixing/treating particle  
groups.

15 2. Background Art

[0003] Previously known techniques and methods are  
currently used for the separation of aggregates into  
particle groups. For instance, gravity classifiers,  
inertial classifiers, centrifugal classifiers, and  
20 cyclone separators are well known and used  
technologies. Amongst other patents, Canadian Patent  
No. 2,257,674, issued on January 7, 2003 to Cordonnier  
et al., discloses an air classifier with centrifugal  
action. Canadian Patent Applications No. 2,068,935 (by  
25 Tyler et al.) and 2,294,829 (by Gruenwald) respectively  
describe an air separator and an air classification of  
water-bearing fruit and vegetable ingredients for peel  
and seed removal and size discrimination.

[0004] Another known separation method is gravity  
30 separation by elutriation. In this process, a  
predetermined particle group is lifted by an airflow  
against the force of gravity. A finer particle group

is collected by an upwardly positioned collector, whereas coarser particles overcome the airflow to be collected at a downwardly positioned collector. The amount and velocity of air has a direct effect on the particle group that is collected by the upwardly positioned collector.

[0005] One of the existent technologies, described in U.S. patents No. 2,003,899 and No. 5,259,510, uses a large volume of blown and sucked air to collect the particles to be filtered. Several steps are performed to knock together the particle stream. Some steps use deflectors and other steps entrain particles with blown or sucked air. Steps wherein air is blown to entrain the particles and allow to collect them further along in a filtration equipment. The sucked air is used to collect the volume of blown air and the entrained particle that are in suspension therein. This method uses relatively large volumes of air for lower-mass particles.

[0006] This previously described method is a dry process, in that the fluid used for the separation is not in a liquid phase. Such systems are advantageous in that no liquid is polluted in the separation process. The cleaning of liquids after particle separation is a costly process, and this results in a clear cost-efficiency advantage for dry processes.

#### SUMMARY OF INVENTION

[0007] It is therefore an aim of the present invention to provide a novel apparatus and method for separating a particle stream into particle groups.

[0008] It is a further aim of the present invention to cause a dilution of a particle stream and is related to enhance the separation of the particle stream

components having different masses, into particle groups.

[0009] It is a further aim of the present invention to provide a novel apparatus and method for mixing a particle groups into a particle stream.

[0010] It is a further aim of the present invention is related to an apparatus that the apparatuses for separating a particle stream into particle groups, and for mixing particle groups into a particle stream use minimum space and fluid ~~air~~ volume so as to be cost and space efficient.

[0011] It is a further aim of the present invention to provide a novel apparatus and method for separating particle streams into particle groups.

[0012] It is a further aim of the present invention to reduce a need for conventional dust collection systems.

[0013] A few factors are considered in creating separation, mixing equipment. For instance, it is desired that the amount of fluid used in the process be kept low. The fluid that is used for the separation, will lose the particles depending of the momentum of the fluid flow it carries ~~in suspension~~ for settling.

[0014] Also, the separation is a sub-process of larger processes, and is often performed in limited-space areas with the larger process. It is therefore desired to keep the dry-separation equipment as space efficient as possible.

[0015] In a broad aspect, the invention provides a method for separating/mixing a particles stream, the stream of particles flowing substantially along a stream flow direction. The method comprises directing a

5 flow of fluid towards the stream of particles, the flow of fluid flowing substantially along a flow of fluid direction, the flow of fluid having a high pressure and momentum creating a jet stream momentum such that the jet momentum of the fluid produces a force impacting the particles stream causing the particles to move in a direction substantially parallel to the flow of fluid.

10 [0016] In some embodiments of the invention, the method includes directing a flow of fluid towards the stream of particles, the flow of fluid flowing substantially along a flow of fluid direction, the flow of fluid having a momentum such that the fluid produces a force impacting on the particles stream causing the particles to move in the diluting treatment chamber in a direction substantially parallel to the flow of fluid while the fluid produces the separating force to move over a distance longer than the width of the diluting treatment chamber dimension in a direction substantially parallel to the flow of fluid after the fluid has produced the jet stream force, these force being of a magnitude and a duration such that:

20

[0017] the components of the particles stream are substantially separated from each other by the flow of fluid; and

25 [0018] the distance is substantially longer than the width of the dilution treatment chamber .

[0019] For example, the flow of fluid has a high pressure producing the jet stream and momentum force, impacting particles stream for separating/mixing.

30 [0020] In another broad aspect, the invention provides an apparatus for processing a stream of particles. The apparatus comprising:

- [0021] - a substantially longitudinal parallelipipedic dilution treatment chamber, the dilution treatment chamber defining an upper chamber and an opposed lower chamber end, the dilution treatment chamber having a chamber passageway extending between the upper and lower chamber ends;
- [0022] - a source of compressed fluid; and
- [0023] - a nozzle 14, for creating a jet stream, the nozzle including
- 10 [0024] - a nozzle inlet 40, in fluid communication with the source of compressed fluid;
- [0025] - a nozzle outlet 41, in fluid communication with the chamber passageway for releasing the jet stream into the chamber dilution treatment chamber;
- 15 [0026] - a nozzle passageway 43, extending between the nozzle inlet and the nozzle outlet.
- [0027] For the purpose of this description, the term particle applies both to solid particles and to fluid.
- 20 Therefore, the above-described method and apparatus are both applicable to the processing of liquids.
- [0028] Therefore, and non-restrictively, in accordance with the present invention, there is provided an apparatus for separating a particle stream into particle groups and mixing particle groups in a particles stream. The apparatus comprising includes a dilution treatment chamber 12, defining an for instance a parallelipipedic upstanding channel passageway (20), dilution treatment chamber 12, having a particle stream inlet 21, at a top end, and a first-particle group outlet at a bottom end, the dilution treatment chamber
- 25
- 30

12, ~~channel~~ being adapted to receive a particle stream at the ~~particle~~ inlet 21, such that the particle stream falls toward the dilution treatment chamber and first particle group outlet 22; a transfer chamber casing 13, for instance parralelipipedic and adjacent to the dilution treatment chamber 12, and defining a transfer chamber 30, adapted to receive a the second particle group separated from the particle stream; a transfer chamber 13, sharing a wall 23, with the dilution treatment chamber 12; at least one transfer aperture 24, second particle group outlet laterally positioned with respect ~~to the channel~~ to of the dilution treatment chamber 12, and allowing fluid communication between the longitudinal dilution treatment transfer chamber 12, and the longitudinal transfer chamber ~~channel~~ 13; a distributor 14, in passageway the dilution treatment chamber 12, and at least one nozzle 14, for creating the impact force produce by fluid pressure-jet action ~~channel~~ situated between the particle stream inlet 25, and ~~the~~ at least one transfer aperture 24, second particle-group outlet for spread out, breaking down the particle stream and distributing the particle stream over a surface area of the dilution treatment chamber ~~channel~~ 12, and; at least one dilution treatment chamber fluid flow aperture (25) in the dilution treatment chamber 12, and below the distributor 14, adapted to create a lateral fluid flow jet between the dilution treatment chamber 12, and the transfer chamber 13, and ~~the channel~~ so as to impact and entrain a second particle group, from the ~~channel~~ dilution treatment chamber and to project the selected particles groups away through the transfer aperture 24, and second-particle group outlet to the transfer chamber outlet 31, with a first-particle-group remaining in the dilution treatment chamber 12, ~~channel~~

for and exiting through the dilution treatment chamber,  
first-particle-group outlet 22, the apparatus being  
adapted to be connected to a positive pressure source  
to create the rate and pressure of the fluid flow  
5. stream.

[0029] Further in accordance with the present  
invention, there is also provided a method for  
separating a particle stream into particle groups, or  
mixing particle groups comprising the steps of:

10 [0030] i) spreading out, breaking down the particle  
stream by subjecting the particle stream to lateral  
forces distributing a particle stream over a surface  
area of the dilution treatment chamber by subjecting to  
a fluid jet distributor 14, for horizontal dilution

15 [0031] ii) vertically diluting the particle stream  
by directing the particle stream in the dilution  
treatment chamber 12, to a falling condition  
accelerated by means of gravity;

[0032] iii) projecting/entraining a particle group  
20 away from a remainder of the particle stream by  
creating a fluid flow jet at predetermined magnitude,  
creating a lateral force action across the particle  
stream in said falling condition which impact and  
accelerate and move the particles stream in other  
25 direction. The forces impacting a particle stream in  
order to move and project them across the surface area  
and within the volume of the dilution treatment chamber  
12. This action increases the space between the  
particles for an important mass dilution of the  
30 previous masses of the particles stream. The dilution  
allows projection of a group of particle away from a  
particle stream remainder for the separation process  
and let the different groups of components exit at

separate locations. Simultaneously the fluid jet also projects the different particles in all directions in the dilution treatment chamber for mixing. These processes may also use any suitable treatment fluid for  
 5 treating the particle stream and;

[0033] iv) collecting the particle group and the remainder of the particle stream at separate locations.

[0034] Still further in accordance with the present invention, there is provided an apparatus for at least  
 10 one of mixing and treating particle and/or fluid stream, comprising a generally parallelepipedic dilution treatment chamber 12, defining a parallelepipedic upstanding passageway 20, channel  
 15 having an inlet 21, at a top end, and an outlet 22, at a bottom end, the passageway 20, channel being adapted to receive said particle and/or fluid streams at the inlet such that said particle and/or streams fall toward the outlet;

[0035] at least one dilution treatment chamber fluid  
 20 flow aperture 25 connected to the nozzle outlet having an adjustable cross section area, in the dilution treatment chamber 12, adapted to create a generally lateral flow of at least one of a fluid jet and particle jet defined as a free jet fluid leaving an  
 25 outlet will expand and decelerate. The jet momentum is transferred to the particles stream and the distance of deceleration depend of the cross section area and the magnitude of the jet leaving the nozzle within the passageway 20, channel enhancing separation and to  
 30 create a turbulence in the passageway 20, channel for at least one of mixing said particle and/or fluid streams and treating separating said particle and/or fluid streams, whereby a mixture and/or treated separated matter will exit the passageway 20, channel



at the outlet 22; and a positive pressure source connected to the nozzle which is connected to the dilution treatment chamber fluid flow aperture to create the lateral flow force of the at least one of  
 5 the fluid and the particle with a jet having a high pressure.

[0036] Still further in accordance with the present invention, there is provided a method for at least one of treating and mixing particle and/or fluid streams,  
 10 comprising the steps of: i) vertically diluting particle and/or fluid streams by directing particle and/or fluid streams to a falling condition; ii) creating a lateral flow of fluid and/or a particle jet force across the particle and/or fluid streams in  
 15 said falling condition for at least one of mixing the particle and/or fluid streams by a turbulence resulting from the lateral flow of fluid and/or particle jet stream, and treating separating said  
 20 mixture and/or treated separated matter below the lateral flow.

[0037] In some embodiments of the invention, the method and apparatus lets the particles decelerate, agglomerate and settle in the transfer chamber 13, and  
 25 exiting by the transfer chamber outlet 31.

[0038] Advantageously, the claimed apparatus is able to process relatively large quantities of particles relatively fast.

#### BRIEF DESCRIPTION OF THE DRAWINGS

30 [0039] Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration a preferred embodiment thereof and in which:

[0040] Fig. 1 is a schematic view of an apparatus for separating/mixing a particle stream in accordance with a preferred embodiment of the present invention, and of a method for separating/mixing the particles stream;  
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[0041] Fig. 2 is a perspective view of the apparatus in accordance with a preferred embodiment of the present invention;

[0042] Fig. 3 is a further perspective view of the apparatus of Fig. 1;  
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[0043] Fig. 4 is a perspective view of a nozzle to be used with the apparatus of the first embodiment;

[0044] Fig. 5 is a perspective view of the apparatus in accordance with a second embodiment of the present invention;  
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[0045] Fig. 6 is a perspective view of a lateral particle separator to be used with the apparatus of the second embodiment;

[0046] Fig. 7 is a perspective view of a recuperator tray of the apparatus;  
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[0047] Fig. 8 is a schematic view of impeller used to create horizontal dilution ~~and separation~~ of a particle stream in accordance with an alternative embodiment of the present invention;

[0048] Fig. 9 is a schematic view of a laterally reciprocating strainer in accordance with a further alternative embodiment of the present invention; and  
25

[0049] Fig. 10 is a schematic view of an apparatus for separating/mixing particles stream in accordance with a still further alternative embodiment of the present invention.  
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[0050] Fig. 11 is a schematic view of a transversal section through the dilution treatment chamber 12, in order to clarify the details of the movable side wall of the passageway 20.

# 5 DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0051] It is pointed out that the present invention is associated with the separating or mixing, or any combination thereof, the of different components having different properties of a particles stream. For example, the components have different masses. The term "particles stream" is broadly used herein to designate a different component mass of particles, granules, pellets, and other elements of different mass and volume gathered together. Various uses of the present invention are defined hereinafter, for which the components masses that which are is separated/mixed is referred to as particle stream, unless stated otherwise.

[0052] Also, the present invention uses a high pressure force of a fluid jet, creating a jet momentum with a large kinetic energy. This energy is transferred at least in part to particles stream components to move, distribute, project, entrained, and settle the different components of the particle stream.

[0053] Referring to the drawings, and more particularly to Fig. 1, an apparatus for separating/mixing a particle stream into particle groups is generally shown at 10. The apparatus 10, shown in the drawings is a typical apparatus according to the invention. The reader skilled in the art will readily appreciate that many other geometric shapes and configurations are within the scope of the invention. The apparatus 10, has a substantially parallelipedic

dilution transfer chamber 12, a substantially parallelipipedic transfer chamber 13 adjacent to the dilution treatment chamber 12, sharing a wall 23, between the transfer chamber 13 and the dilution treatment chamber 12, ~~has a dilution treatment chamber 12, a transfer casing 13 adjacent to the dilution treatment chamber 12~~ a nozzles 14 serially mounted on the dilution treatment chamber 12, and a pre-treatment module 15. It is pointed out that the nozzles 14 are affixed with letters in various figures, whereby reference to the nozzles 14 will relate to all nozzles (e.g., nozzles 14A, 14B and 14C), while reference to a specific one of the nozzles will include an affixed letter.

[0054] The dilution treatment chamber 12 performs a dilution of a particle stream by producing space between the different component gathered together in the particle stream using a fluid jet force. The fluid flow is a fluid that is involved in the separation, mixing particles stream. The magnitude of the force is created by the pressure of the fluid jet. More specifically, the force creates a momentum in the jet stream which is transferred in part on the particles stream. In some embodiments of the invention, the fluid jet force creates a relatively large distance between the particles and distribute in the volume of the dilution treatment chamber. The extent to which the particles stream are diluted on many parameters. For example, the following parameters influence the dilution: 1) adjustment of the surface area of the dilution treatment chamber12; 2) adjustment of the fluid jet magnitude; 3) number of stage of projection of the fluid jet; 4) length of the dilution treatment chamber 12, among others. All these parameters

determine the dilution rate of the particle stream masses.

[0055] The nozzle jet trough the dilution treatment chamber and the speed acceleration by the gravity force of the particle stream, and hosts a step of separation/mixing of the particle stream into particle groups. As described;

[0056] An impact is created by a high pressure of the flow of fluid which produce the jet force and magnitude. The jet action is defined as a expand and decelerate jet momentum having fast moving energy. The force produces an action of acceleration and a change in the direction on the particles stream. For example, the formula is: "force equal the mass of the fluid times acceleration produced by the pressure of the fluid through the nozzle outlet opening and resulting in a magnitude of the force".

[0057] One other step to increase the dilution rate of the particle fluid stream is performed when the stream reaches the inlet of the passageway 20, of the dilution treatment chamber 12. At least one nozzle distributor 14, dilute many times the previous mass concentration of the particle/fluid stream. In some embodiments of the invention wherein a nozzle 14, is present, the nozzle creates a fluid jet, which in turn creates a force through the action of the high pressure of the flow of fluid. As described in further details in this document, jet momentum created is thereby transferred to the components of the particles/fluids stream to move the components for distributing the particles/fluids stream on the cross section area of the dilution treatment chamber.

10058] After this step, the particle stream accelerates as it falls through the passageway 20, of the dilution treatment chamber 12. This further multiply the dilution of the particles stream to  
 5 obtain a dilution rate of the particles stream suitable for separating/mixing particles.

10059] The dilution achieved is related to the volume of the dilution treatment chamber 12. This length allows for increasing the previous speed of the  
 10 particle/fluid stream, which is accelerating under the influence of gravity. Since the particle stream accelerates, mass conservation requires that the particle stream be diluted. This multiplication of the dilution is related on the speed up to which the  
 15 particle stream is accelerated. The length of the dilution treatment chamber 12, and the location of the nozzles 14, are selected such that a dilution factor suitable to achieve successfully the separation/mixing to perform is obtained. After this step, the particle  
 20 stream reaches at least one other nozzle that also produces a flow of fluid jet force impacting through the particle stream in the dilution treatment chamber 12, to move the particle or fluid. The total distance over which the particles are moved depends on the  
 25 masses of the different components of the particle stream and the magnitude of the force.

10060] At this stage, the particles/fluids stream has been diluted many times and its speed has been increased many times. The particles contain relatively  
 30 large amounts of kinetic energy because of their relatively increasing speeds. Therefore, the high pressure related to high speed produced by a nozzle 14, is set for creating a relatively force to move and project the particle stream over the dilution treatment

chamber distance in transversally direction of the particle fluid stream in the falling direction. To perform this jet force action, which is related to the square of the speed at the outlet 41, of the nozzle 14, by the mass of the fluid flow, this method uses a relatively small amount of treatment fluid having a relatively high pressure. The flow of fluid is then able to move laterally at least a portion of the particle stream without floating and entraining big amounts of air with the particle. When the jet momentum decelerate with respect to the surface area of the nozzle outlet, the separated groups of particles slow down and falls in the transfer chamber by losing its momentum.

[0061] The transfer chamber casing 13 is in fluid communication with the dilution treatment chamber 12 and receives particle group separated from the remainder of the particle stream in the dilution treatment chamber 12.

[0062] The nozzles 14 are used to inject project fluid, which ~~breaks down~~ distributes the mass of particle stream and/or enhance the dilution of the particle stream in the dilution treatment chamber 12. Moreover, the nozzles 14 are used to inject/project fluid jet which separates particle stream into the particle groups, and mixing particles groups.

[0063] The pre-treatment module 15 is used to guide and-accelerate the particle stream toward the dilution treatment chamber 12, such that the particle stream will have predetermined some velocity. The velocity will cause a horizontal dilution of the particle stream.

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# DILUTION TREATMENT CHAMBER 12

[0064] Referring concurrently to Figs. 1, 2 and 3, the typically parallelepipedic dilution treatment chamber 12 is shown having an upstanding elongated shape, and defines a substantially elongated vertical passageway ~~channel~~ 20 of rectangular having a passageway cross-section. Although a rectangular passageway cross-section, is described, any other suitable cross-section shapes are contemplated. The passageway ~~channel~~ 20 has an inlet 21 at a top end thereof and an outlet 22 at a bottom end thereof. The dilution treatment chamber 12 shares a wall 23 with the preferably parallelepipedic transfer chamber casing 13. Transfer apertures 24, lateral outlets positioned opposite the dilution treatment chamber fluids aperture 25, are provided in the wall 23, such that the dilution treatment chamber 12 and the transfer chamber casing 13, are in fluid communication. Moreover, the dilution treatment chamber 12 may vary in cross-sectional dimensions. For instance, appropriate translating mechanisms may be provided so as to increase/decrease a length or width of the cross-section parameters of the dilution treatment chamber 12.

[0065] The dilution treatment chamber 12 also has pressure-differential apertures 25 (herein three apertures, i.e., dilution treatment chamber fluid flow apertures), two of which are horizontally positioned opposite the transfer aperture lateral outlets 24 in the wall 23, between the dilution chamber 12 and transfer chamber casing 13.

# TRANSFER CHAMBER 13

[0066] Referring concurrently to Figs. 1, 2 and 3, the transfer chamber casing 13 defines an inner



transfer chamber 30. The inner transfer chamber 30 has a funnel-shaped outlet 31 at a bottom end thereof, so as to collect a particle group in suspension and allow deceleration and mass reconcentration for settling in the transfer chamber 30.

[0067] Referring to Fig. 5, a lateral particle separator 60, in accordance with another embodiment of the present invention, is received in the inner transfer chamber 30 of the transfer chamber casing 13.  
The lateral particle separator 60 will be described in further detail hereinafter, and is used to cause a further particle group separation.

#### NOZZLE 14

[0068] Referring concurrently to Figs 1, 2 and 3, the nozzle 14B and 14C are positioned opposite the transfer aperture lateral outlets 24 of the dilution treatment chamber 12. The nozzle 14, in a preferred may take various geometric shape and configurations.  
For instance, the nozzle configuration are connected to a pressure source so as to produce and project, inject a gaseous fluid (e.g., air or any other suitable gas, whereby reference will be made non-restrictively hereinafter to air or gaseous fluid) into the passageway channel—20 of the dilution treatment chamber 12.

[0069] Referring to Fig. 4, one of the nozzle 14 is illustrated in greater detail. The nozzle 14 has an inlet 40, by which it is connected to a pressure source, and an outlet 41 of elongated ~~rectangular~~ shape. The nozzle 14 has a diffusing body 42 between the inlet 40 and the outlet 41.

[0070] In a preferred embodiment of the present invention, the diffusing body 42 has an accumulator

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portion 43 connected to the inlet 40, and tapered diffusing sectors 44 between the accumulator portion 43 and the outlet 41. The diffusing sectors 44 are used in order to create a substantially uniform diffusion of fluid ~~air~~ out of each of the nozzle 14.

[0071] A gate 45 is displaceable vertically for the adjustment of the height of the outlet and surface area 41. A connection flange 46 is used to secure the nozzle 14 to the dilution treatment chamber 12 opposite the pressure-differential apertures 25. It is also seen in Figs. 2 and 3 that the gate 45 can be accessed from an exterior of the apparatus 10, thereby enabling the rapid adjustment of the outlet size of the nozzle 14 from an exterior of the apparatus 10.

[0072] Displacement of the gate 45 controls, at least in part, the rate and velocity of the fluid so that the pressure of the fluid is a predetermined velocity and magnitude. The magnitude controls at least in part the predetermined force to achieve separating/mixing of the particles stream.

[0073] The above-described configuration of the nozzle 14 enables a high-pressure, low-volume output of gaseous fluid into the dilution treatment chamber 12 to produce a high impact on the particles stream for projecting the particles at different distances depending of their masses and momentum and other characteristics.

[0074] In other words, a stream of particles flowing substantially along a stream flow direction is diluted by a flow of fluid directed towards the stream of particles, the flow of fluid flowing substantially along a diluting flow of fluid direction and transversal of the particles stream direction.

[0075]     The flow of fluid has a high pressure such that the fluid produces a high impact on the particles causing the particles to move over the dimension of the dilution treatment chamber in a direction substantially parallel to the flow of fluid while the fluid produces the force and to move over a longer distance in a direction substantially parallel to the flow of fluid jet stream after the fluid has produced the force. The fluid force is of a magnitude and duration such that the particles are substantially separated from each other by the flow of fluid jet of the longest distance which is substantially larger than the width dimension of the dilution treatment chamber dimension.

[0076]     In some embodiments of the invention, the movement of at least some of the particles caused by the momentum of the flow of fluid is such that the fluid jet speed decelerates with the group of particles that have been impacted by the fluid jet. In other embodiments of the invention, the high impact is such that the longest distance is larger than the distance performed in the dilution treatment chamber dimension.

[0077]     Accordingly, the output of gaseous fluid will decelerate at a high rate, so as to project and entrain in some instances described hereinafter a given selected particle group out of the dilution treatment chamber 12, and to avoid enhancing creating turbulence in the transfer chamber 30. Such turbulence would slow down the settling process in the transfer chamber 13, for instance, if the apparatus 10 were used for classifying particle groups.

#### PRETREATMENT MODULE 15

[0078]     Referring concurrently to Figs. 1, 2 and 3, the pre-treatment module 15 is positioned at the inlet

21 of the dilution treatment chamber 12. The pre-treatment module 15 conveys the particle stream from a particle stream source, such as conveyor C, to the inlet 21 of the dilution treatment chamber 12. More specifically, the pre-treatment module 15 will be used to produce specific inlet conditions for the particle stream.

[0079] In a preferred embodiment of the present invention, the pre-treatment module 15 has a slide 50, sloping downwardly towards the inlet 21 of the dilution treatment chamber 12. A deflector 51 is positioned between the slide 50 and the inlet 21 of the passageway channel 20. The deflector 51 has a generally horizontal launch surface, but may also be oriented otherwise. As seen in Figs. 2 and 3, the slide 50 tapers towards the inlet 21 of the dilution treatment chamber 12, so as to have an outlet 22, width generally equal to the inlet 21, width of the passageway channel 20 of the dilution treatment chamber 12. ~~The slide 50 is preferably provided with guiding rails 52 (Figs. 2 and 3).~~ The particle stream reaching the slide 50 is preferably uniformly distributed toward the inlet 21 of the dilution treatment chamber 12, ~~and the guiding rails 52 are provided to this effect.~~

[0080] A further slide splitter 53 is optionally provided above the slide 50 so as to dampen the fall of the particle stream from the conveyor C. The slide 53 will absorb a portion of the downward force, and will absorb the lateral velocity transmitted from the conveyor C to the particle stream, such that the particle stream reaches the dilution treatment chamber 12 at predetermined velocity parameters.

[0081] It is contemplated to provide various geometry configuration to the pre-treatment module 15.

For instance and non restrictively, the slide 50 is herein illustrated as being generally a flat, inclined surface. However, it is contemplated to provide the slide 50 with a downwardly-tapered ~~frusto-conical~~ shape, whose ~~smallest~~ cross-section would meet the inlet 21 of the dilution treatment chamber 12. Moreover, for such an embodiment, the slide 53 preferably has an upright ~~conical~~ shape.

#### THE OPERATION OF THE APPARATUS IN SEPARATION

[0082] Now that the various components of the apparatus 10 have been described, ~~a separation operation~~ of the apparatus 10-is set forth.

[0083] Referring concurrently to Figs. 1, 2 and 3, a particle stream is fed by the conveyor C to the apparatus 10. The particle stream has a lateral velocity and will accelerate downwardly when leaving the conveyor C due to gravitational forces.

[0084] The slide 53 will absorb a portion of the downward force of the particle stream, and stop the lateral velocity of the particle stream that had been transferred to the particle stream by the action of the conveyor C. The mass of particle stream is directed by the slide 53 toward the slide 50 of the pre-treatment module 15, at generally predetermined velocity conditions.

[0085] Upon reaching the slide 50, the particle stream will be guided by the guiding rails 52 so as to be conveyed uniformly towards the dilution treatment chamber 12 as a result of the downward slope of the slide 50. The downward slope of the slide ~~splitter~~ 50 will cause the particle stream to accelerate.

[0086] The deflector 51, having a launch surface, will deflect the particle stream so as to initiate a

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break-up-of the particles stream. A ~~lateral~~ dilution will be the result of the deflection of the particle stream by the deflector 51. Accordingly, the particle stream will reach the dilution treatment chamber 12, having been subjected to a mass break-up and to a horizontal dilution.

[0087] The particles stream then falls in the ~~channel~~ passageway 20 of the dilution treatment chamber 12. The gravity velocity acceleration will cause a vertical dilution of the particle stream and will multiplicate the previous dilution caused by the nozzle 14.

[0088] A first one of the nozzles 14, namely nozzle 14A, will inject/project ~~air~~ fluid within the dilution treatment chamber 12, passageway ~~channel~~ 20 of the ~~dilution treatment chamber 12.~~, so as to ~~cause by a break-up of spread out~~ the mass of particle stream into particle groups, ~~(i.e., breaking down the mass of particle stream)~~ dilute and/or creating space between the particles groups. This nozzle 14A is also referred to as a distributor, as it will be distributing the particle stream over a surface area of the ~~channel~~ dilution treatment chamber dimension 20-12. As an alternative of nozzle 14, a distributors 14, the apparatus 10 may be provided with vibrating strainers, impellers, or the like, as will be illustrated hereinafter.

[0089] The particle stream, having been subjected to a horizontal and a vertical dilution ~~(i.e., break-up or distribution)~~, will be crossing a horizontal flow of air fluid jet substantially perpendicular to the particle stream in said falling direction as injected/projected by the ~~second~~ at least one others nozzles 14B, and the optional nozzle 14C. The nozzles

14B and 14C inject project air fluid, at a predetermined and pressure through the dilution treatment chamber fluid aperture 25, which are positioned opposite to the transfer chamber aperture lateral outlets 24, such that the fluid air will project particles group selected from the particle stream in the dilution treatment chamber 12 carry the finer particles carried through the particle stream and/or out of the channel passageway 20, through the transfer chamber aperture lateral outlets 24, and into the inner transfer chamber of the transfer casing 13, in a high ratio of particle to-air fluid concentration. The projected fluid air injected by the nozzles 14 is at the predetermined pressure, such that the other groups of particles have not been projected out and remain in the particle stream depending. In other words, some groups of particles are projected over the dilution treatment chamber distance, which creates a separation of these groups of particles from other particles present in the stream of particles. Particle group will not entrained out of the channel passageway 20 by the air fluid flow. The dilution that has taken place previously is an important factor for the separation and mixing of the fine different particles from the coarse particles. The magnitude of the pressure of fluid air projected/injected will have a direct effect on the particles groups being withdrawn from the particle stream in the dilution treatment chamber channel 20. It is pointed out that the vertical distance from the inlet 21 to the nozzle 14B is an essential factor in diluting the particle stream to facilitate the subsequent separation/mixing of the particle groups so as to increase fluid/particle contact.

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[0090] Although plurality of three nozzles (namely 14A, 14B and 14C) are described, the number of nozzles 14 is variable according to the present invention. The apparatus 10 is operative with a single nozzle 14 ~~exposed~~ connected to an aperture 25, but a plurality of nozzles 14 may be serially added on the dilution treatment chamber 12 to increase the efficiency of the operation taking place within the dilution treatment chamber 12.

10 [0091] Thereafter, the selected fine particle group exits through the transfer chamber outlet 31 at the bottom of the ~~inner~~ transfer chamber 30 of the transfer casing 13 after settling, whereas the ~~coarse~~ remaining particle stream particle group continues its drop into  
15 the dilution treatment chamber 12 ~~toward the outlet 22~~.

#### THE OPERATION OF THE APPARATUS IN MIXING/TREATING SEPARATING

[0092] As mentioned previously, the apparatus 10 of the present invention is usable ~~can also be used for~~ mixing, and/or ~~treating~~ separating particles and/or fluid streams. Therefore, a ~~mixing/treating~~ an operation of the apparatus 10 is set forth.

[0093] Referring to Fig. 1, particle and/or fluid streams to mix and treat separate are fed by the conveyor C, and possibly other conveyors or particle and/or fluid sources (not shown) to the apparatus 10.  
25 The particle and/or fluid streams have a lateral velocity and will accelerate downwardly when leaving their source due to gravitational forces as similarly set for the separate process, just different force  
30 adjustment will take place as described previously.

[0094] ~~The slide 53 will absorb a portion of the downward force of the particle and/or fluid streams,~~



and stop the lateral velocity of the particle and/or fluid streams that had been transferred thereto by the action of the conveyor C or other possible source. The particle and/or fluid are directed by the slide 50 toward the slide splitter 53 of the pre-treatment module 15, at generally predetermined velocity conditions.

[0095] Upon reaching the slide 53, the particle and/or fluid streams will be guided by the optional guiding rails 52 (Fig. 2), so as to be conveyed uniformly the dilution treatment chamber 12 as a result of the downward slope of the slide splitter 50. The downward slope of the slide splitter 50 will cause the particle and/or fluid streams to accelerate.

[0096] The deflector 51, having a launch surface, will deflect the particle and/or streams horizontally. A lateral dilution will be the result of the deflection of the particle and/or fluid streams by the deflector 51. Accordingly, the particle and/or fluid streams will reach the dilution treatment chamber 12, having been subjected to a horizontal dilution.

[0097] The particle and/or fluid streams then falls in the channel passageway 20 of the dilution treatment chamber 12. The gravity will cause a vertical dilution of the particle and/or fluid streams.

[0098] A first one of the nozzles, namely nozzle 14A, will laterally project/inject fluid, or any other suitable fluid or particle jet, within the channel passageway 20 of the dilution treatment chamber 12 so as to cause a turbulence movement of components of particle stream for another step of dilution a mix or a treatment of the particle and/or fluid streams. The fluid/particle injected and projected by the nozzle 14A is of predetermined pressure depending of the

25  
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adjustment of the pressure source and the nozzle outlet gate 41, to produce the different jet force through the particle stream so as to have a variable effect relative to the size, mass and other characteristics of the particles and/or fluid streams. The nozzle 14 and 14A projects/injects air or any other suitable fluid, at high pressure and low volume.

[0099] The opposite transfer chamber apertures lateral outlets 24 are used in the mixing process of the apparatus 10. The nozzles 14B and 14C are optionally used with the opposite transfer chamber aperture lateral outlets 24 being blocked with a fluid at high pressure 26, so as to create further turbulence, as it is contemplated to provide a plurality of the nozzles 14 to enhance the mixing of particle and/or fluid stream in the passageway channel 20, or for treating separating the particle and/or fluid streams. Additional nozzles may also be added to the apparatus 10.

[00100] Thereafter, the mix or treated separated matter, resulting from the mix/treatment of the particle and/or fluid streams, continues its drop into the dilution treatment chamber 12 toward the outlet 22.

#### ADDITIONAL COMPONENTS OF THE APPARATUS 10

[00101] It is contemplated to provide additional components to the apparatus 10 in order to optimise the separation of the particle stream into particle groups.

[00102] Referring to Figs. 5 and 6, a lateral distributor selector is generally shown at 60. The lateral distributor selector 60 is positioned in the transfer chamber 30 of the transfer casing 13. Referring more specifically to Fig. 6 in which all reference numerals are shown to simplify Fig. 5, the

lateral distributor selector 60 is shown defining three upstanding sectors 61, each converging to a segmented outlet portion 62. Each of the sector 61 has a respective collecting surface 63 upon which particles coming from the dilution treatment chamber 12 will be collected. A flow of fluid outlet 64 is provided downstream of the upstanding sectors 61 to allow an appropriate flow of fluid, that will not impede on the lateral flow of fluid (or gaseous fluid) out of the lateral outlets 24 of the dilution treatment chamber 12.

[00103] More specifically, the lateral distributor 60 operates with the principle that the distance travelled by the particles transported carried in the flow of air fluid from the dilution treatment chamber 12 is a function of the particle size parameters (e.g., surface area, mass) and the momentum of the flow of fluid jet. Accordingly, coarser heavier mass of particles will travel a shorter distance than finer ones, whereby the coarser particles will be collected by the upstream sector 61. Therefore, a further particle group separation takes place with the lateral distributor 60. The hence separated particle groups are collected separately at the segmented outlet portion 62.

[00104] Referring to Figs. 3 and 7, recuperation trays 70 are provided below each of the transfer chamber apertures lateral outlets 24 of the dilution treatment chamber 12. More specifically, it is possible that particles groups that should selectively remain with the dilution treatment chamber 12 are deflected out of the transfer chamber aperture lateral outlets 24. It is anticipated that these coarser groups of particles will not travel a long distance out of the transfer chamber aperture lateral outlets 24 due

to their size mass parameters and momentum. Accordingly, the recuperation trays 70 are provided to collect these particles, as they are positioned directly below the transfer chamber apertures 24.

5 These particles are returned to the dilution treatment chamber 12 by the sloping shape of the recuperation trays 70.

[00105] Moreover, the recuperation tray 70 illustrated in Fig. 7 have various configurations also effects a particle separation. More specifically, the recuperation tray 70 as has a first sector 71 and a second sector 72. The first sector 71 collects the particles that should not have left the dilution treatment chamber 12, whereas the second sector 72  
15 collects rapidly falling particles, of a grade just below that of the particle group remaining within the dilution treatment chamber 12. It is pointed out that the second sector 72 is connected to its own outlet.

[00106] Also, the recuperation tray 70 may be pivotally connected at a bottom edge thereof to the wall of the dilution treatment chamber 12. This would enable adjustment of an angle of the recuperation tray 70 with regard to the vertical, as a function of the particle stream/ particle group being separated.

25 [00107] Fig. 12 8 and ~~13~~ 9 illustrate alternative ~~to~~ of the nozzle 14A ~~for use in the dilution process~~. In Fig. 8, an impeller is shown at 80. In Fig. 9, a laterally reciprocating strainer is generally shown at 90. Both these alternatives will cause a horizontal  
30 dilution of the particle stream. Other alternatives include ~~fans~~, electrostatic or magnetic emitters (e.g., in accordance with the type of particles stream being treated), as well as any mechanical or ultrasound system.

[00108] Fig. 11 illustrate a transversal section of the dilution treatment chamber 12, where is detailed the transversal movement of passageway side wall 20, used for adjusting the cross sectional area of the dilution treatment chamber 12.

[00109] It is also contemplated to inject additives to the particle stream being diluted in the dilution treatment chamber 12. For instance, an aperture such as one of the dilution treatment chamber pressure-differential apertures 25 can be used with a suitable injection system (e.g., blower pressure source and conduit combination) to inject any kind of treatment agent colour (e.g., in the form of a powder) to the particle stream being diluted in the dilution treatment chamber 12, or to particle groups being mixed therein.

[00110] It is also contemplated to provide a plurality of the apparatus 10 in series, with a conveying system transporting/conveying the output of an upstream one of the apparatus 10 to a downstream one. Alternatively, a pair (or more) of the apparatus 10 may be positioned in parallel and/or share a common transfer chamber 30, to collect a specific particle group. In such a case, the transfer chamber 13 could be used to mix a particles group from a first dilution treatment chamber 12 with particles group of a second dilution treatment chamber 12.

[00111] For instance, referring to Fig. 10, an apparatus in accordance with an alternative embodiment of the present invention is generally shown at 10'. The apparatus 10' is similar to the apparatus 10 of Fig. 1 in that the apparatus 10' has a dilution treatment chamber 12, 102, nozzles 14, 104 (herein four pluralities nozzles for the dilution treatment chamber 12, 102), and a pre-treatment module 15'. The pre-

treatment module 15' shows a different shape (e.g., with a conical slide 53'55', but operates in a fashion similar to that of the pre-treatment module 15. The apparatus 10' has an other transfer chamber easing 13' in which a secondary separation/mix is performed.

[00112] More specifically, the transfer chamber easing 13' has a transfer plate 100, a dilution treatment chamber 102, nozzles 104, and another transfer chamber subeasing 106. The particles group reaching the transfer chamber easing 13' from the dilution treatment chamber 12 will drop into the inlet of the dilution treatment chamber 102, or will settle onto the transfer plate 100, to then reach the inlet of the dilution treatment chamber 102.

[00113] Optionally, the transfer plate 100 is provided with a vibrator 108 so as to avoid having particles collect thereon. The transfer plate 100 could also be provided with a low adherence coating, such as PTFE.

[00114] The dilution treatment chamber 102 is illustrated having the nozzles 104A, 104B, and 104C. The nozzle 104A serves the same function as the nozzle 14A of Fig. 1, namely to distribute break-down the particles group that has reached the dilution treatment chamber 102. The nozzle 104A can be replaced with other devices, such as those illustrated in Figs. 12 8 and 13 9.

[00115] The nozzles 104B and 104C serve the same function as the nozzles 14B and 14C of Fig. 1, and are thus positioned opposite the transfer aperture lateral outlets 110, through which a particle group will be forced out, to reach the transfer chamber subeasing 106 and settle therein. The removed particles group will

exit through outlet 112, whereas the remaining particles group in the dilution treatment chamber 102 will exit through dilution treatment chamber outlet 114. Recuperation trays 116 are adjustable similarly  
5 to the recuperation trays 70 of the preferred embodiment.

[00116] Accordingly, the output of the apparatus 10' are have many ~~is three~~ particles groups, with particles group exiting from the passageway outlet 20, 102, and  
10 transfer chamber outlet 112 ~~subeasing 106 being the finest~~. It is pointed out that the gaseous fluid magnitude output ~~of~~ at the nozzles 14 and 104 is adjusted in view of the desired ~~size~~ mass of the particles groups. The transfer chamber ~~easing~~ 13' can  
15 be used for separating/ mixing ~~or treating~~, as described previously for the apparatus 10.

#### USES

[00117] Amongst the various process that can take place with the apparatus (10-10') of the present  
20 invention, it is contemplated to separate, treat, classify (with an initial step of separation), mix, add, vaporise, clean, calibrate, or eliminate group of fines particles from particle streams. Other treatments, such as painting, coating, sandblasting, ~~or~~  
25 cleaning, and so forth can be effected with the apparatus 10-10' of the present invention. Existing batch processes, such as the injection of gas or chemicals into soft drinks, can be converted to continuous processes using the present invention.

30 [00118] The differential pressure in the dilution treatment chamber 12 can be controlled electronically and the apparatus 10 may be combined to magnetic,

electrical, ultrasound, electronic, and electromagnetic systems.

[00119] The apparatus 10-10' can be used with mineral, vegetable, biological, or organic aggregates, as well as with fertilisers, treatment or transformation residues, waste, food products, drugs and other pharmaceutical products, powders, agriculture related products, chemical or metallurgical products, compost, plastics and composites, paper, soil and bio-soil, ashes, crushed stone, ceramics, coal.

[00120] The apparatus 10-10' of the present invention is relatively small. Accordingly, it is possible to place the apparatus 10-10' at various parts of a process due to these advantageous features. The apparatus 10-10' enables large quantities of particle fluid streams to be treated in a relatively limited amount of space, with little wear of material, low energy consumption and, in some embodiments, no moving parts (i.e., depending on the choice of the type of dilution).

[00121] The apparatus 10-10' can be used as part of a multi-step or multi-pass process. ~~Moreover although, For instance, the preferred embodiment includes only a settling cavity for the collection of particles, an outflow of air for the particles remaining in suspension can be added as an option.~~ The apparatus 10-10' is made of rigid materials, such as metals, polymers, and so forth. It is pointed out that aside from the slide 53, the apparatus 10-10' goes through limited wear.

[00122] It is within the ambit of the present invention to cover any obvious modifications of the embodiments described herein, provided such



modifications fall within the scope of the appended claims.